KALMUS

RF POWER AMPLIFIERS

TECHNICAL MANUAL

MODEL 121CA

KALMUS ENGINEERING INTERNATIONAL, LTD.
21820 87TH SE, WOODINVILLE WA 98072, U.S.A.
TELEPHONE 206/485-9000 TELEX 24-7028 FAX (206) 486-9657

KALMUS
R F POWER AMPLIFIERS

FINAL TEST DATA

Model 121CA Serial No. 05058-1

Description R.F. POWER AMPLIFIER

Date 5-5-88 Invoice No. 92546

Customer BATTELLE PACIFIC NORTHWEST LABORATORIES

Frequency Range .5 - 40 MHZ

Power Gain 53 DB

Gain Flatness < ± 1.5 DB

Power Output 250 - 300 WATTS

Harmonics ≥ 20 DB DOWN @ 200 W

Spurious 20 DB DOWN VSWR Set

~~DC~~ AC Input Required 115 V. AC

INSPECTION CERTIFICATION:

KALMUS ENGINEERING INTERNATIONAL certifies that all applicable standards of materials and workmanship have been fully complied with during the manufacture of this device and that the finished product meets or exceeds the Company's final test and quality control specifications standards.

Witnessed by: T.W Date May 4, 1988

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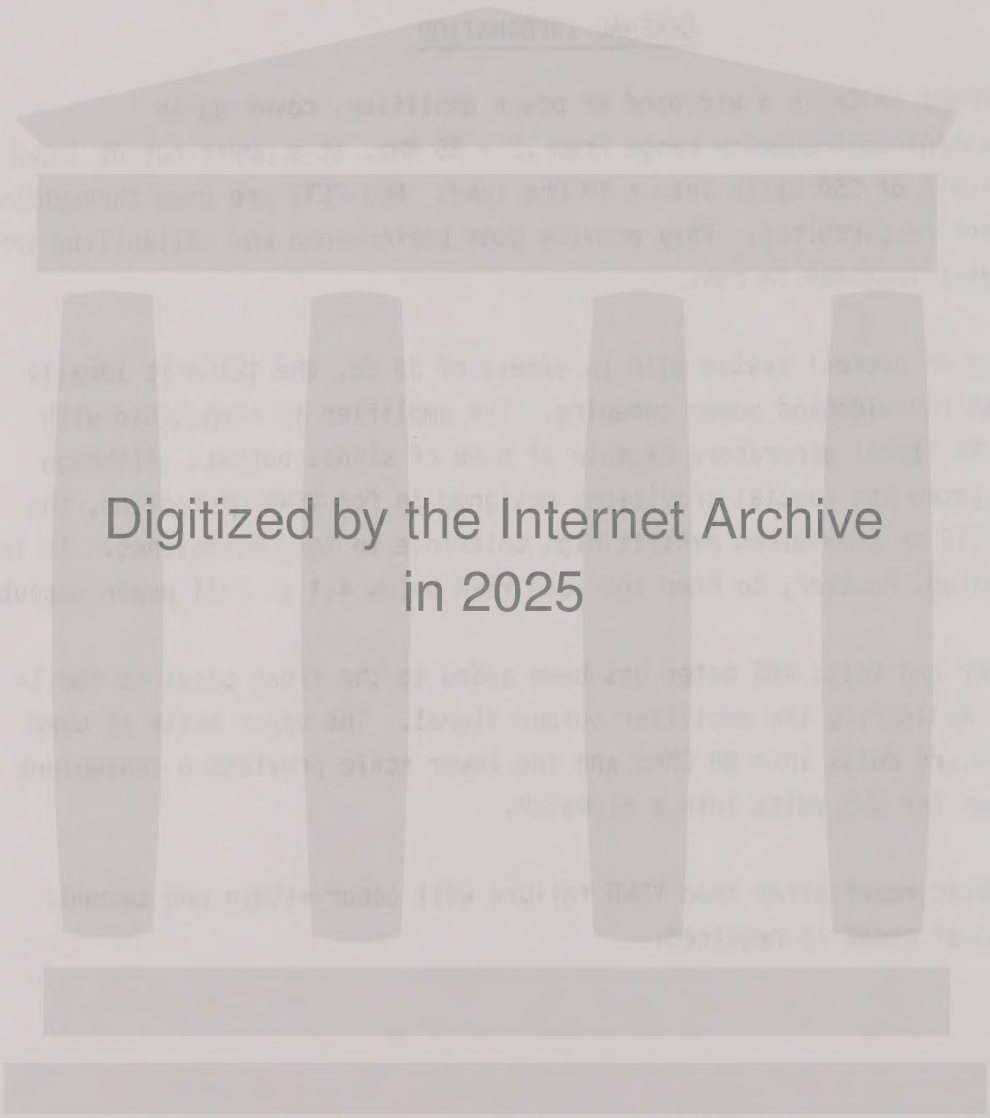
GENERAL INFORMATION

The Model 121CA is a wideband RF power amplifier, covering an instantaneous frequency range from .5 - 35 MHz, at a power output level in excess of 250 Watts into a 50 Ohm load. MOS-FETS are used throughout the entire circuitry. They provide good performance and reliability for a modest increase in cost.

Having an overall system gain in excess of 53 dB, the 121CA is ideally suited for wideband power sweeping. The amplifier is compatible with most RF signal generators capable of 5 mW of signal output. Although the system has special provisions designed in for VSWR protection, the MOS-FETS by themselves exhibit high tolerance to load mismatches. It is suggested, however, to keep the load VSWR below 4:1 at full power output.

A Power and Volts RMS meter has been added to the front panel to facilitate monitoring the amplifier output signal. The upper scale is used to measure Watts into 50 Ohms and the lower scale provides a convenient readout for RMS Volts into a mismatch.

Automatic reset after load VSWR failure will occur within one second. No manual reset is required.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SPECIFICATIONS MODEL 121CA
MOS-FET RF POWER AMPLIFIER

FREQUENCY RANGE	: 0.5-40MHz, Broadband
POWER OUTPUT	: 250 Watts CW and Pulse Minimum 350 Watts Saturated
POWER GAIN	: 53dB Minimum
GAIN FLATNESS	: ± 1.5dB Maximum
MODE OF OPERATION	: Class A Linear
DRIVE LEVEL REQUIRED	: 2-5mW for full Output
INPUT/OUTPUT IMPEDANCE	: 50 Ohm nominal
INPUT VSWR	: 2:1 Maximum
OUTPUT VSWR	: 2:1 Maximum
HARMONICS	: 20-30dB at 200 Watts 16-26dB at 300 Watts
TWO-TONE IMD	: 30dB typical 3rd Order
SPURIOUS OUTPUTS	: 65dB down from Carrier Minimum
SIGNAL RISE TIME	: 2 Microseconds Maximum
SIGNAL FALL TIME	: 1 Microsecond Maximum
PULSE DROOP	: 2% Maximum
PROTECTION	: Temperature & Load Mismatch
VSWR PROTECTION	: Works into any Load Impedance without shutdown
ALARMS	: Visual and Audible
METERING , Watts	: 0-200 Watts direct (upper scale) 0-400 Watts x2 (upper scale)
Volts RMS	: 0-100 Volts RMS (lower Scale)
CONNECTORS	: Type "N" Female
COOLING (Self-contained)	: Forced Air, rear panel
AC POWER REQUIRED	: 100-240VAC, 1KVA Single Phase
SIZE (L x W x H)	; 17 x 19 x 7 Inches 43 x 48 x 18 cm
WEIGHT	: 48 lbs, 22Kgs

POWER METER

A diode-type sampling meter is provided to permit handy monitoring of the output signal. The meter is calibrated in Watts on the upper scale for 50 Ohm loads. If any other loads are suspected, it is recommended to use the lower scale calibrated in Volts RMS. This voltage reading will be accurate for any load within ± 10% if calibration is checked directly at the front panel output connector only. For mismatched load at distant locations, the meter accuracy will be greatly reduced.

VSWR PROTECTION (A3 & A5)

A closed-loop type protection circuit has been incorporated to protect the final output transistors in case of a severe load mismatch. It consists of:

a. A Bi-Directional Coupler
b. A Forward/Reflected Comparator and Auto Reset
c. Visual Alarms
d. Power Supply Cutback

In case of a severe mismatch, the bi-directional coupler senses both forward and reflected power levels and converts them into DC voltages. These two voltages are fed to Pins 2 and 9, respectively, of the comparator PC board. With R4 (threshold) set to 3:1 VSWR (or approximately .3V) on Pin 8 of U1-A, the large voltage on Pin 9 overcomes the threshold set voltage and caused Q1 collector to go low, biasing TB1-D2 to Ground. This action causes the power supply voltage to drop from 28V down to 19-20 Volts, thus permitting the amplifier to handle very high mismatches. Q2 will also go low, causing the VSWR LED I1 to flash on and off. At the same time, the audio beeper will sound at the same pulsing rate as the LED.

U2 is an auto reset. It continuously sends a reset pulse to D3, at the rate of once every second. If the mismatch condition has been removed, the reset pulse will then cause the circuit to reset itself and the alarms will stop flashing or beeping. TB1 - A2 diode will again be in a forward bias mode and normal operation will be restored.

If the VSWR condition has not as yet been removed, then the auto reset will not succeed in resetting the system. It will keep trying at the rate of once every second.

CIRCUIT DESIGN

The system consists of five basic blocks:

a. 28V Regulated Power Supply
b. 250 Watt Power Amplifier
c. Watt into 50 Ohm/Volts RMS Meter
d. VSWR Protection Circuit

REGULATED POWER SUPPLY (DUAL 28V)

The power supply is a self-contained assembly. It has been factory adjusted for 28 - 30 VDC. A 25 Ampere DC fuse, located on the rear panel protects the system in case of transistor failure.

RF POWER AMPLIFIER

A signal at J1 input connector, if within the .5 - 35 MHz frequency range, is fed to a pin attenuator located inside of the amplifier case via a short piece of coaxial cable. C1 is a coupling capacitor. Q1 is the preamplifier stage, boosting our signal by approximately 15 dB with some high frequency compensation in the emitter circuit. The output is fed through a capacitor into the gate of Q2 through C4. Here, a low frequency attenuator is inserted into the drain-gate circuit (R15, C9, L2) to reduce excess low frequency gain without affecting the high frequencies. C13 couples the output of Q2 to the gate of Q3, via a 9:1 impedance transformer T1. The bias for the output stage (Q4-Q7) is set by R36, R47, R48 & R39 for a total drain current of 16 Amperes from the 28 Volt supply (4 Amperes through each FET). Phase combining and load matching is accomplished with T8 and T9 coaxial broadband transformer. Gain in Q2= 13 dB, Q3= 13 dB and 12 dB in the final stage.

PLACING EQUIPMENT IN OPERATION

Connect a 50 Ohm load capable of handling 500 Watts of CW power to the output connector. Connect a 50 Ohm signal source (minimum of 3 mW) to the input connector. Reduce the signal source output to minimum. Verify that your AC line voltage agrees with the internal wiring of the 121CA, note the serial number plate. Turn equipment "ON". The AC "ON" light should illuminate and the fan (blower) should be heard clearly picking up speed.

Watch the panel meter and increase the signal source output until a meter reading is observed. If your load is a good 50 Ohm load, you can read the output power directly off the meter scale.

CAUTION: NEVER RUN FULL POWER WITH THE LOAD DISCONNECTED. THIS MAY CAUSE PERMANENT DAMAGE TO THE OUTPUT TRANSISTORS.

FUSES

An AC line fuse is located in the rear panel. If it blows, chances are your amplifier has a problem. It is suggested that a check be performed prior to replacing the fuse to avoid damage to the equipment.

COOLING

Under no circumstances should the air flow be permitted obstruction for longer than ten minutes. The internal temperature of the heatsink and transistors may reach a critical stage, enabling the temperature protection circuit which will shut down operation. Reset is automatic after sufficient cooling has taken place.

PLEASE NOTE: The cooling fan is a 115 VAC type, even for the 220 VAC users. The fan is connected in such a way across the power supply primary as to assure 115 VAC to it at any line voltage wiring.

PARTS LIST
MODEL 121CA

FINAL ASSEMBLY (88093)

REFERENCE	QTY	DESCRIPTION	PART NUMBER
	1	Cabinet	84066
	1	Panel, Front	84131
	1	Panel, Rear	84067
CB1	1	Circuit Breaker, 5 Amps	52012
SW2	1	Switch, Toggle	52009
R7	1	Potentiometer, 100K Ohm	47081V
	1	Knob	24001
	2	Handle	24003
	2	Ferrule	24004
M1	1	Meter, 200W	29009
I1, 2, 3	3	Lamp, Led Red	39010
IN/OUT	2	Connector, Type "N"	21036
B1,2,3	3	Blower	26002
	2	Screen, Blower	26004
J3/F1	1	Connector, AC Line	21008
F2	1	Fuseholder, DC	51102
F1	1	Fuse, AC, 6A	51006A
F2	1	Fuse, DC, 25A	51025A
T1	1	Transformer	56009
BR1	1	Bridge	43012
C1	1	Capacitor, 39,000uF/50V	15076E
	1	Clamp, Cap. Mounting	69036
A3	1	Coupler, SWC-3 (KEI 88038)	69047
	1	Bracket, Coupler Mounting	84094
	2	Bracket, PC Mounting	84095
	2	Bracket, PC Retaining	84115
	2	Block, PC Retaining	85024
	2	Socket, PC Mounting	21026
	4	Bumper, Rubber	69042
TS1-3	3	Temperature, Switch	52008
	1	Heatsink	46007

PARTS LIST
MODEL 121CA

FINAL ASSEMBLY (88093) - Continued

REFERENCE	QTY	DESCRIPTION	PART NUMBER
Q2	1	Transistor, MJ11012	48022
D2	1	Diode, 13V	43006
C3	1	Capacitor, 220uF/50V	15069E
E1	1	Terminal	40007
	1	Cover, Cabinet	84068
	4	Bracket, Blower Mounting	84131
	2	Bracket, Amp. Mounting	84132
	1	Bar, Blower Support	85030

SUB ASSEMBLIES

	1	Voltage Regulator	88055B
	1	VSWR Protection	88038
	1	Detector	88017
	1	Amplifier Assembly	88083
	1	Final Assembly	88093

DETECTOR ASSEMBLY (88017)

	1	PC Board	86025
R1	1	Resistor, 5.6K Ohm, 2W	47054T
R2	1	Resistor, 10K Ohm, 2W	47059T
R3	1	Resistor, 27 Ohm, ¼W	47010Q
R4	1	Resistor, 390 Ohm, ¼W	47034Q
R5	1	Resistor, 1K Ohm, ¼W	47042Q
R6, 8	2	Resistor, 1K Ohm, Variable	47042V
R7	1	Resistor, 3.9K Ohm, ¼W	47051Q
R9	1	Resistor, 820 Ohm, ¼W	47040Q
C1, 2	2	Capacitor, .47uF/50V Ceramic	15060C
D1	1	Diode	43005

DUAL VOLTAGE REGULATOR (88055B)

	1	P.C. Board, Modified	86038
C2,4,6	3	Capacitor, 22uF/35V Elect.	15065E
C5	1	Capacitor, 47uF/50V Elect.	15067E

PARTS LIST
MODEL 121CA

DUAL VOLTAGE REGULATOR (88055B) - Continued

REFERENCE	QTY	DESCRIPTION	PART NUMBER
R1	1	Resistor, 270 Ohm, 2W	47031T
R2	1	Resistor, 510 Ohm, 2W	47037T
R3, 4	2	Resistor, 10K Ohm, ½W	47059H
R5	1	Resistor, 1K Ohm, 2W	47042T
R6	1	Resistor, 30K Ohm, ½W	47069H
D1	1	Diode, Zener 20V 1N4747A	43013
D2	1	Diode, Zener 9V 1N4739A	43008
D3	1	Diode, Zener 30V 1N4751A	43007
D4,5,6	3	Diode, 1N4003	43001
Q1, 3	2	Transistor, TIP29A	47039
Q4	1	Transistor, 2N2270	48064
TP2	1	Test Point White	69044W
TR1	1	Test Point Red	69044R

AMPLIFIER ASSEMBLY (88083)

	1	P.C. Board	86054
R1,2,21,22	4	Resistor, 51 Ohm, ½W	47017H
R3,9,10,23	4	Resistor, 24 Ohm, ½W	47009H
R4, 24	2	Resistor, 120 Ohm, ½W	47025H
R5, 14,15	3	Resistor, 750 Ohm, ½W	47039H
R6	1	Resistor, 27K Ohm, ½W	47068H
R7	1	Resistor, 1.5K Ohm, ½W	47044H
R8, 16	2	Resistor, 1K Ohm, ½W	47042H
R11	1	Resistor, 27 Ohm, ½W	47010H
R12	1	Resistor, 43 Ohm, ½W	47015H
R13	1	Resistor, 390 Ohm, ½W	47034H
R17	1	Resistor, 300 Ohm, ½W	47032H
R18, 19	2	Resistor, 20 Ohm, ½W	47008H
R20	1	Resistor, 10 Ohm, ½W	47005H
R25	1	Resistor, 270 Ohm, ½W	47031H
R26	1	Resistor, 1K Ohm, Variable	47042V

PARTS LIST

MODEL 121CA

AMPLIFIER ASSEMBLY (88083) - Continued

REFERENCE	QTY	DESCRIPTION	PART NUMBER
T2/T3	1	Transformer Divider	87091
T4, 5	2	Transformer, Base Input	87043
T8/T9	1	Transformer Output Combiner	87092
	3	Ferrite Bead	38002
	2	Ferrite Bead	38009
	8	Ferrite Bead	38016
	16	Ferrite Bead	38018
	4	Ferrite Bead	38019
	1	Heatsink, PCB Mounting	46012

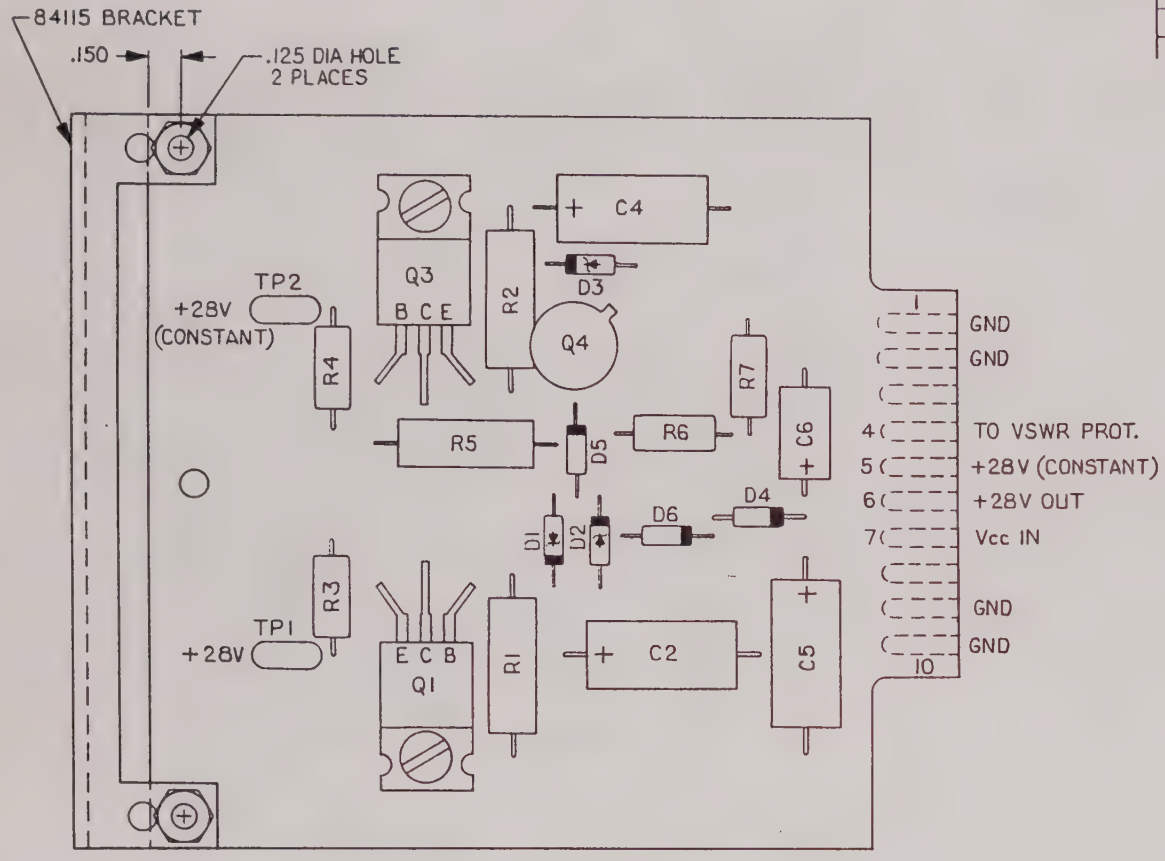
VSWR PROTECTION & RESET (88038) (A3 & A5)

R1, 8, 18	3	Resistor, 47K Ohm, ¼W, 5%	47073Q
R2, 19, 22	3	Resistor, 30K Ohm, ¼W, 5%	47069Q
R4	1	Resistor, 30K Ohm, Variable	47065V
R20	1	Resistor, 56K Ohm, ¼W, 5%	47075Q
R5,9,14,15	4	Resistor, 100K Ohm, ¼W, 5%	47081Q
R6	1	Resistor, 150K Ohm, ¼W, 5%	47083Q
R3,7,17,21	4	Resistor, 220K Ohm, ¼W, 5%	47086Q
R10	1	Resistor, 3.9K Ohm, ¼W, 5%	47051Q
R11	1	Resistor, 4.7K Ohm, ¼W, 5%	47053Q
R12, 24	2	Resistor, 1K Ohm, 2W, 5%	47042T
R13,23,25	3	Resistor, 10K Ohm, ¼W, 5%	47059Q
R16	1	Resistor, 750 Ohm, ½W, 5%	47039H
C1,10,11	3	Capacitor, Elec. 22uF/35V	15065E
C2,3,5,7,8,9,12	8	Capacitor, Ceramic .47uF/50V	15061C
C4	1	Capacitor, Elect. 10uF/50V	15064E
C6	1	Capacitor, Elect. 1uF/50V	15061E
D1,3,4	3	Diode, 1N914 or 1N4148	43003
D5	1	Diode, REF. 13V or 1N4743A	43006
U1(a,b,c,d)	1	IC, LM339N	48008
U2	1	IC, MC1455	48009
Q1, 2	2	Transistor, PNP 2N4402 or 2N4403	48019

PARTS LIST
MODEL 121CA

VSWR PROTECTION & RESET (88038) - Continued

REFERENCE	QTY	DESCRIPTION	PART NUMBER
	1	Socket, IC, 14-Pin	22006
	1	Socket, IC, 8-Pin	22007
TP1	1	Test Point Black	69044B
TP2	1	Test Point Red	69044R
TP3	1	Test Point White	69044W
	1	P.C. Board	86035



REVISION		
A	ADDED CIRCUITRY	7-23-87 MLC

K.E.I. WOODINVILLE, WASHINGTON, U.S.A.

SCALE: 2/1	APPROVED BY:	DRAWN BY DAL
DATE: 6-2-86		REVISED

DUAL VOLTAGE REGULATOR ASSEMBLY

DRAWING NUMBER 994003 A

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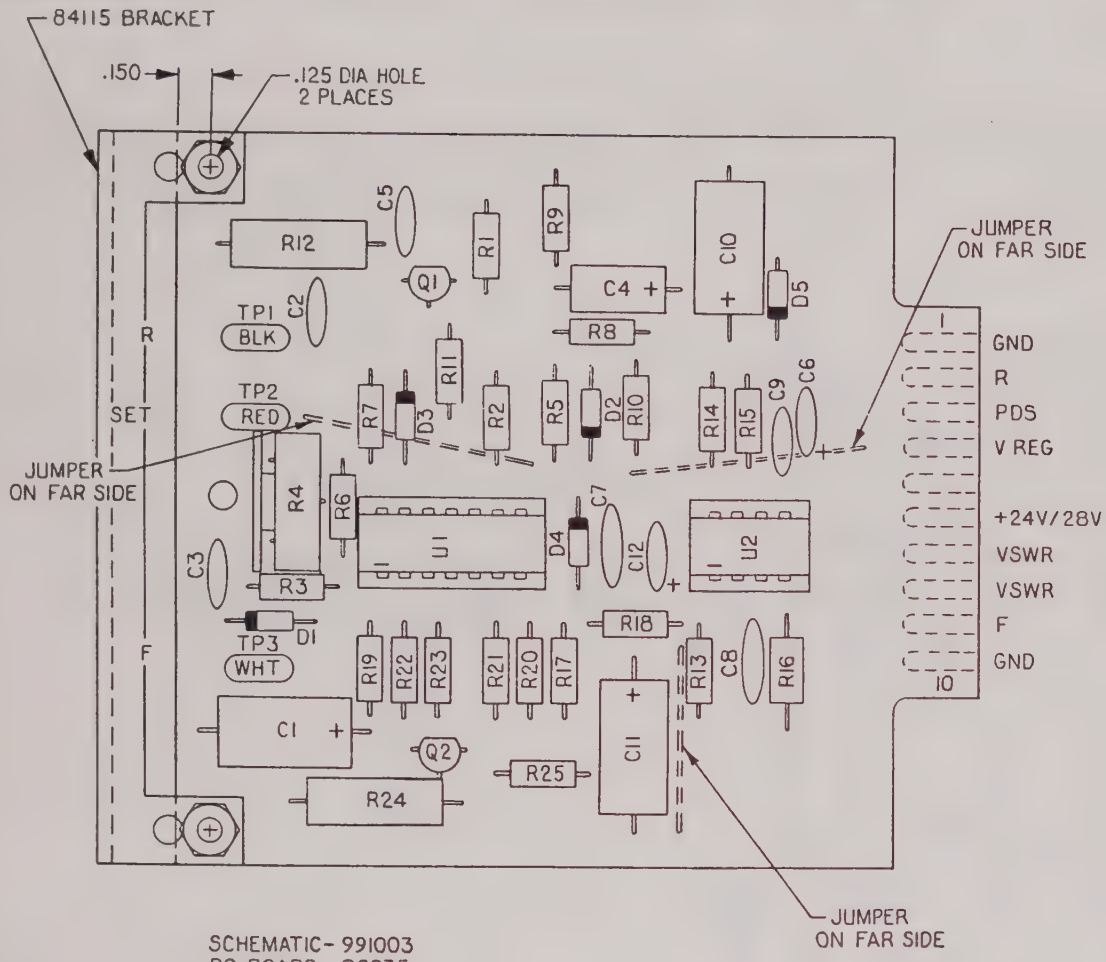

SCHEMATIC- 991003
PC BOARD - 86035

REVISION		
A	REVISED COMPONENT LOCATIONS	6-2-86 DAL
B	ADDED PIN 4 USAGE	7-11-87 DAL

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SCALE: 2/1	APPROVED BY:	DRAWN BY DAL
DATE: 4-23-86		REVISED

VSWR PROTECTION & RESET ASSEMBLY

MODEL 121CR | DRAWING NUMBER 994001 | B

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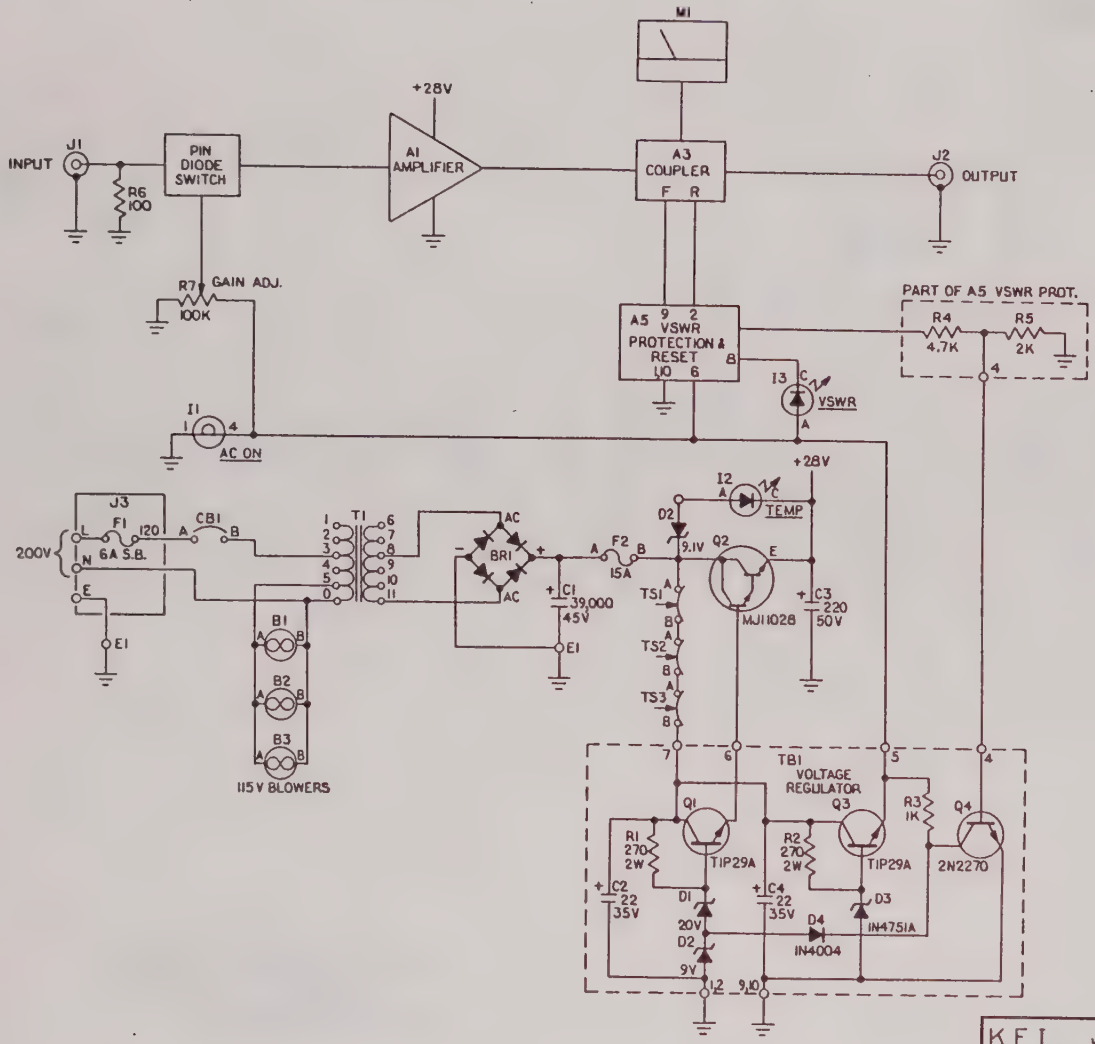

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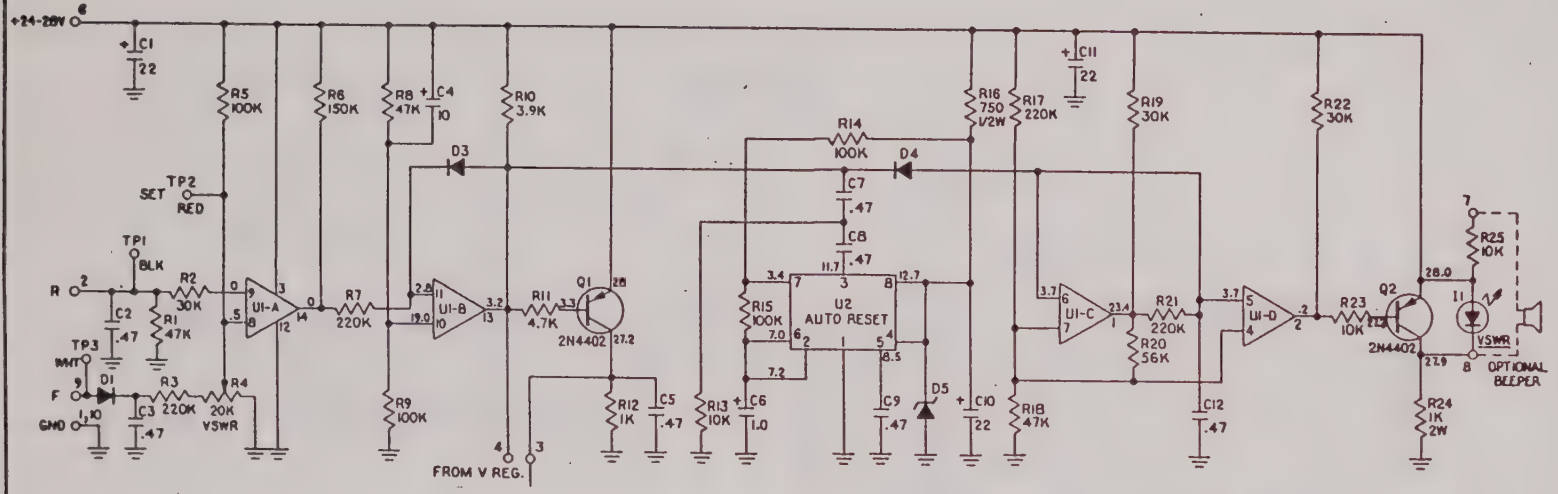
SCALE: NONE | APPROVED BY: | DRAWN BY DAL

DATE: 7-6-87 | REVISED

SYSTEM WIRING—AMPLIFIER, MODEL 121CA

DRAWING NUMBER 991024

REVISION		
A	DELETED D2 & NOTE 6. CHANGED (7) CAPACITOR VALUES	6-10-87
B	ADDED PIN 4	9-13-88



NOTES: UNLESS OTHERWISE SPECIFIED
1. CAPACITOR VALUES ARE IN MICROFARADS
2. RESISTOR VALUES ARE IN OHMS
3. U1 IS LM339M. U2 IS MC1455
4. DIODES D1, D3, D4 ARE TYPE IN914
5. ALL DC VOLTAGES MEASURED TO CHASSIS GND AND TAKE IN POWER-ON MODE

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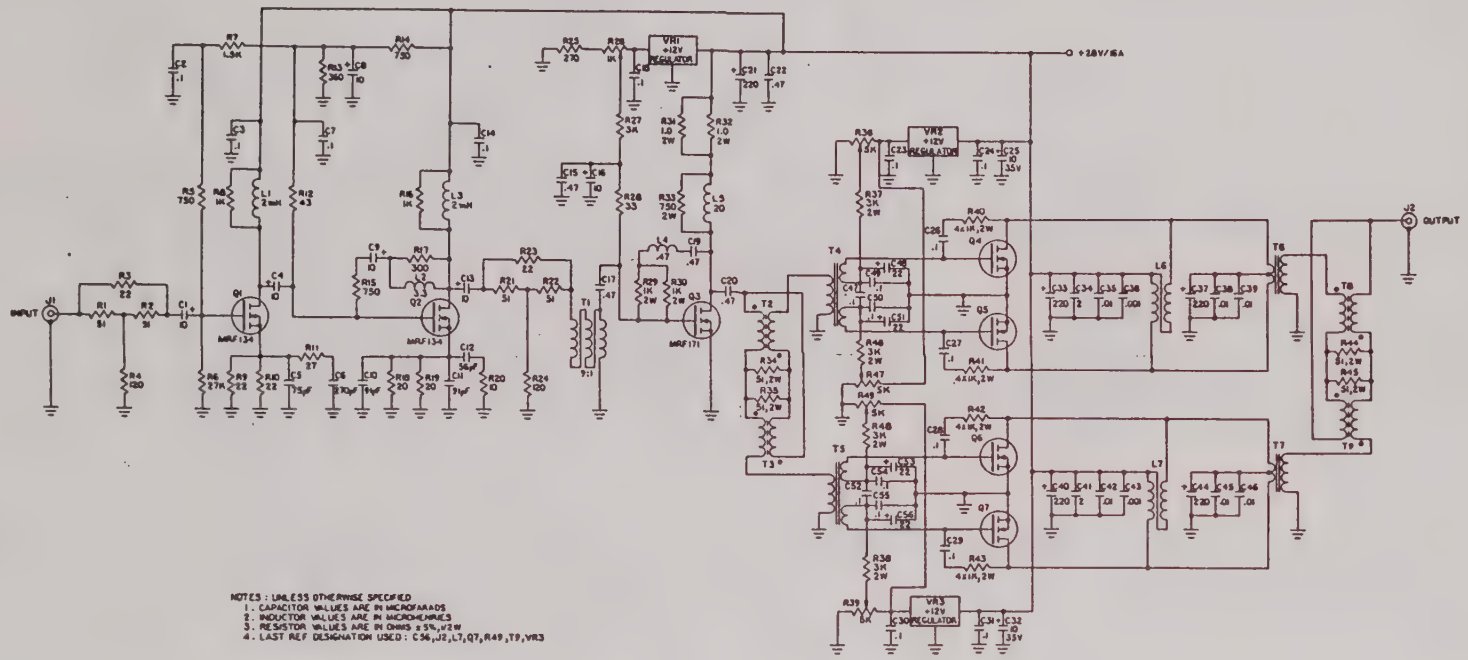
SCALE: NONE | APPROVED BY: | DRAWN BY DAL

DATE: 3-21-88 | REVISED

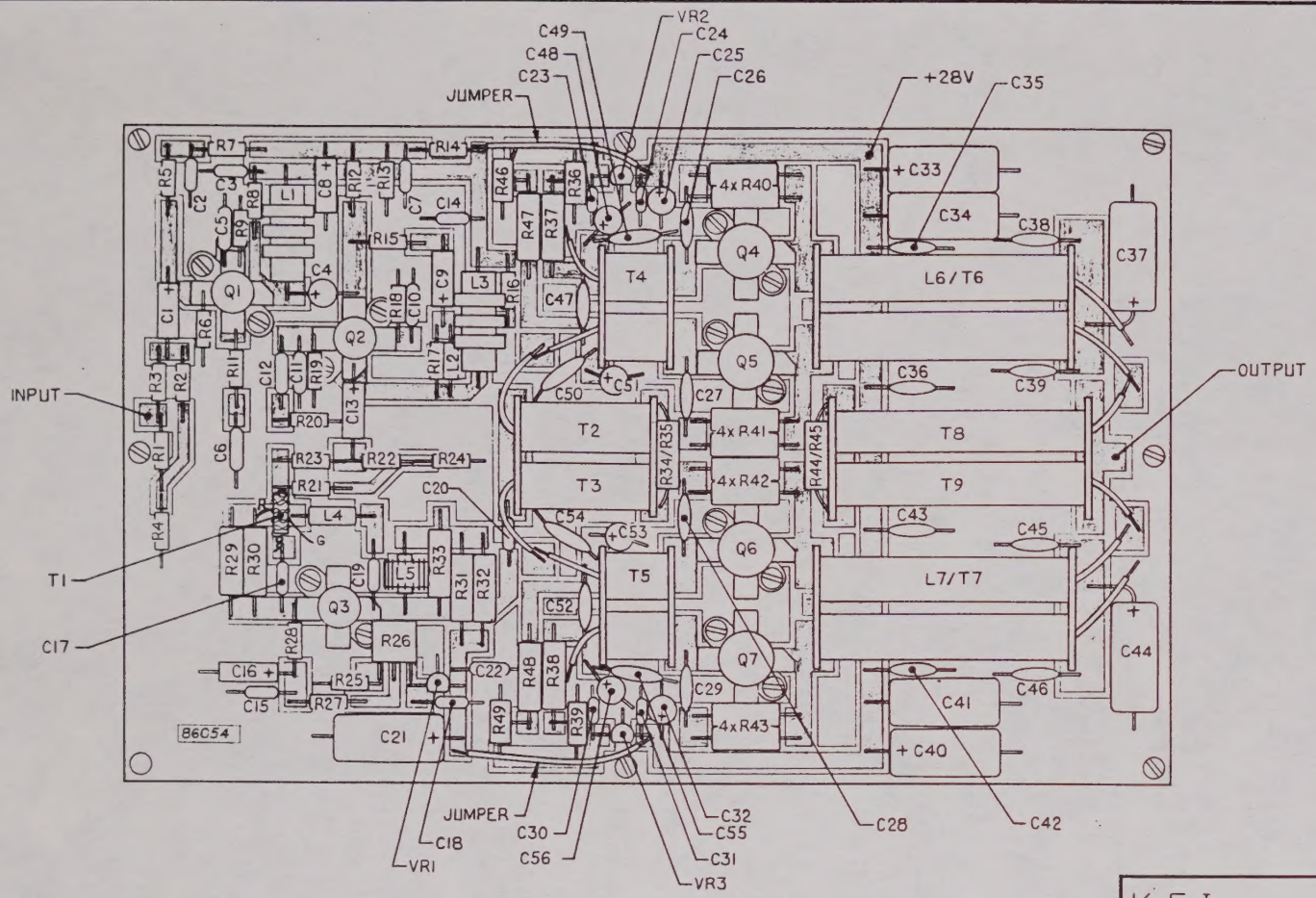
SCHEMATIC-VSWR PROTECTION & RESET

991003 B



NOTES : UNLESS OTHERWISE SPECIFIED
1. CAPACITOR VALUES ARE IN MICROFARADS
2. INDUCTOR VALUES ARE IN MICROHENRIES
3. RESISTOR VALUES ARE IN OHMS ±5%, ½W
4. LAST REF DESIGNATION USED : C56, J2, L7, Q7, R49, T9, VR3

K.E.I.	WOODINVILLE, WASHINGTON, U.S.A.	
NONE		D.A.L.
7-8-87		
SCHEMATIC - AMPLIFIER, .3-35MHz, 300W		
MODEL 121CA		991020



SCHEMATIC:
991020

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DATE: 7-15-87		REVISED	
AMPLIFIER BOARD ASSEMBLY–MODEL 121CA			
		DRAWING NUMBER	994016

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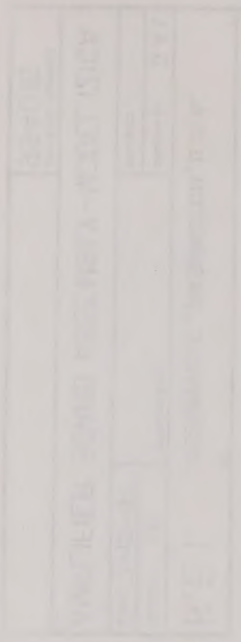

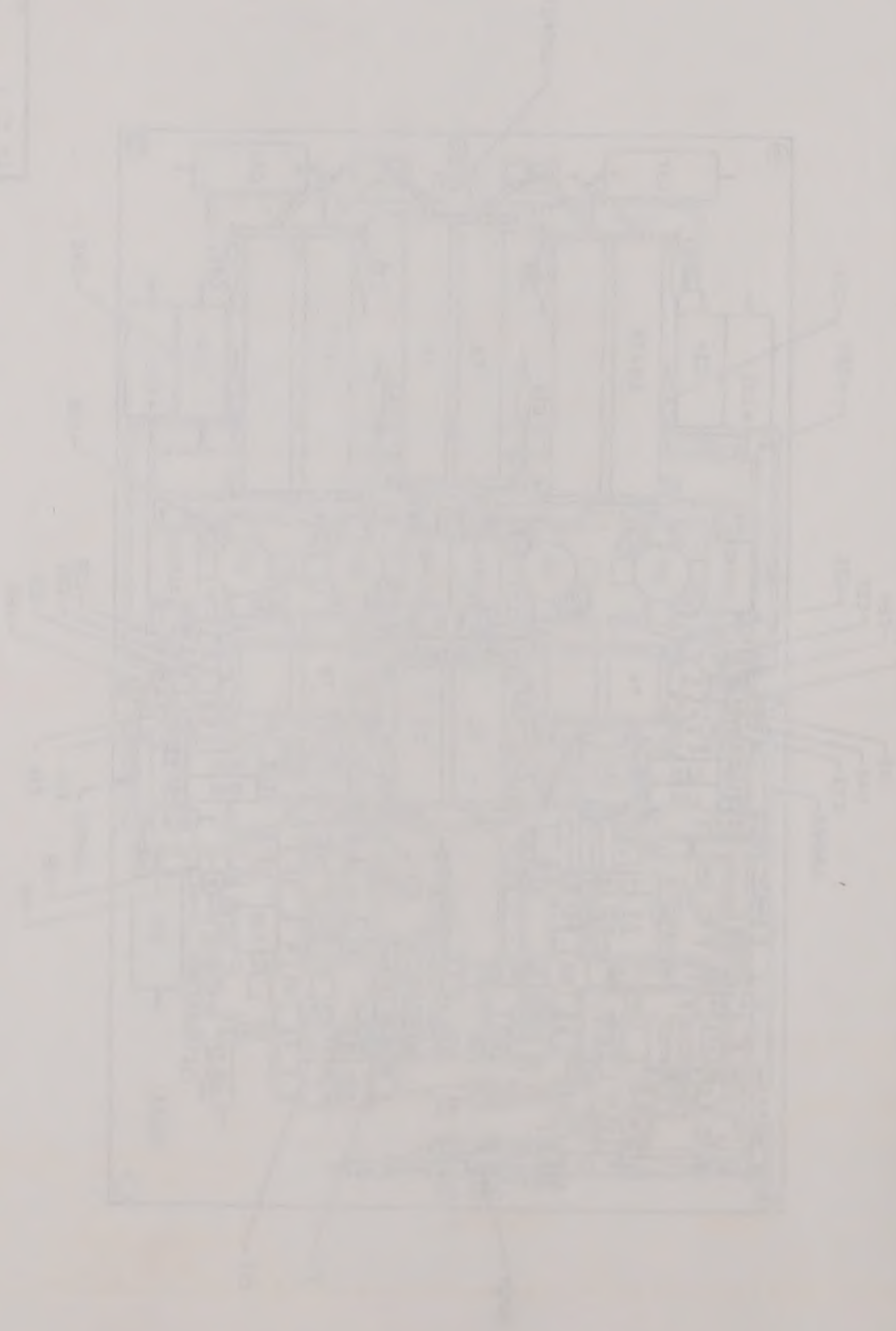

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